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Wipfel

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(54) **SYSTEM AND METHOD FOR CREATING A CUSTOMIZED INSTALLATION ON DEMAND**

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(73) Assignee: **Oracle International Corporation**, Redwood City, CA (US)

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Related U.S. Application Data

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(51) **Int. Cl.**
G06F 9/44 (2006.01)
G06F 9/445 (2006.01)

(52) **U.S. Cl.**
USPC **717/174**; 717/168; 717/177

(58) **Field of Classification Search**
None
See application file for complete search history.

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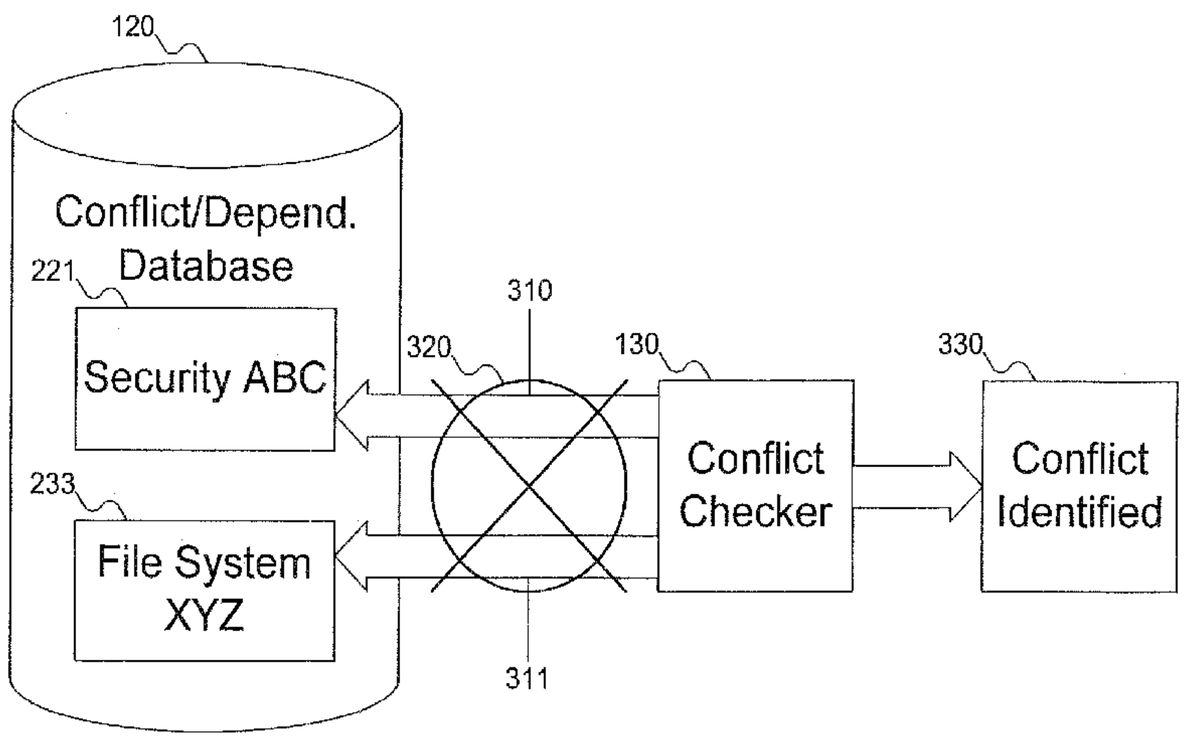
(57) **ABSTRACT**

A customized VM image, for example of Linux software, is created by allowing a user to select packages that the user is interested in installing. During the process, the user is informed if two of the packages that were selected will not be interoperable at run-time. The user is then given an opportunity to resolve the conflict. The user is also informed if selected packages depend on other packages that were not selected in order to run properly, and given the opportunity to include those needed packages in the VM image. Once the selected packages have been validated that they will interoperate and all dependencies are satisfied, the system can build and install the VM image. The VM image can also include applications, and not just packages used in assembling an operating system image.

25 Claims, 13 Drawing Sheets



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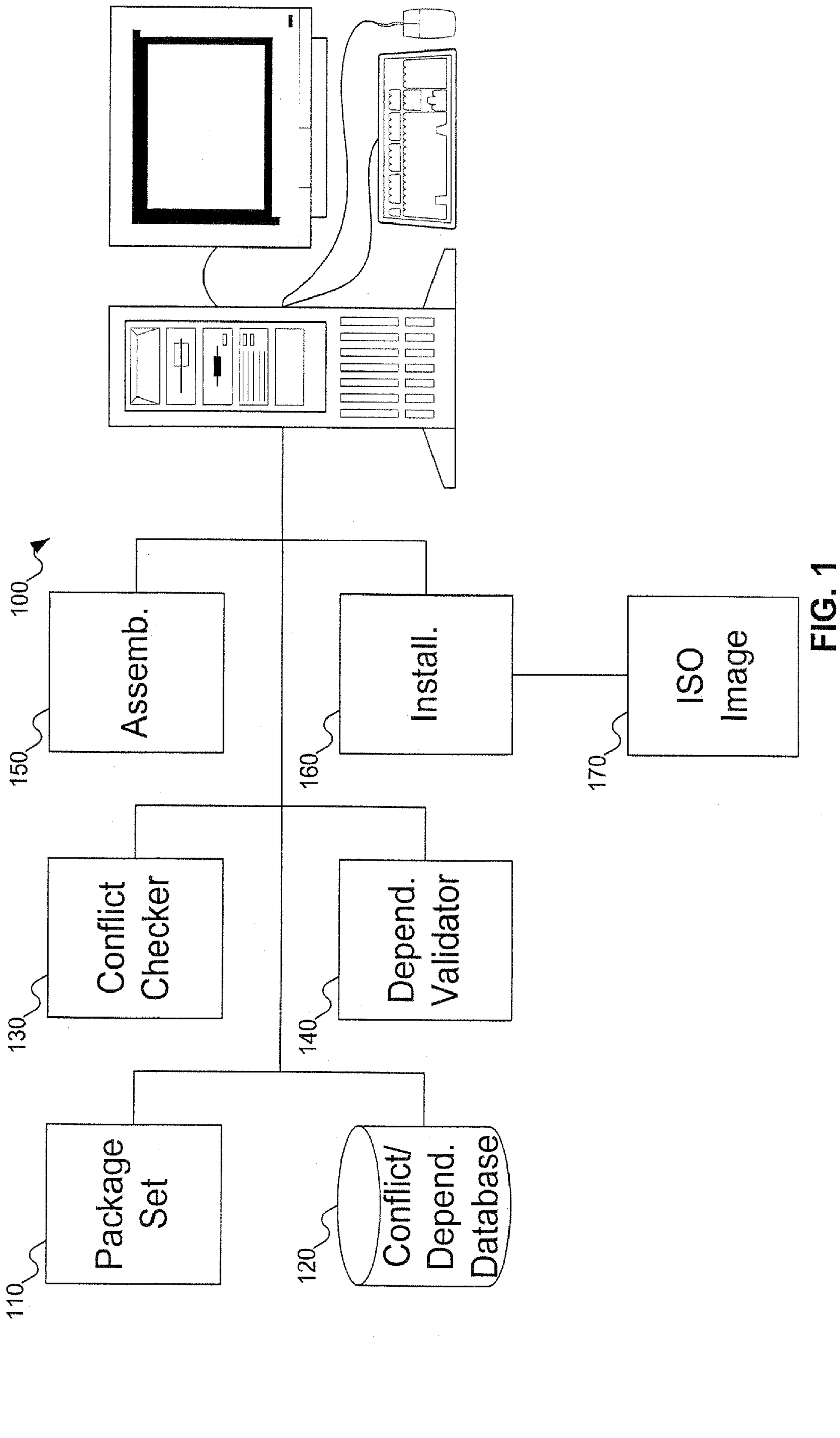
100
Assemb.
150
Install.
160
ISO Image
170
Conflict Checker
130
Depend. Validator
140
Package Set
110
Conflict/ Depend. Database
120

FIG. 1

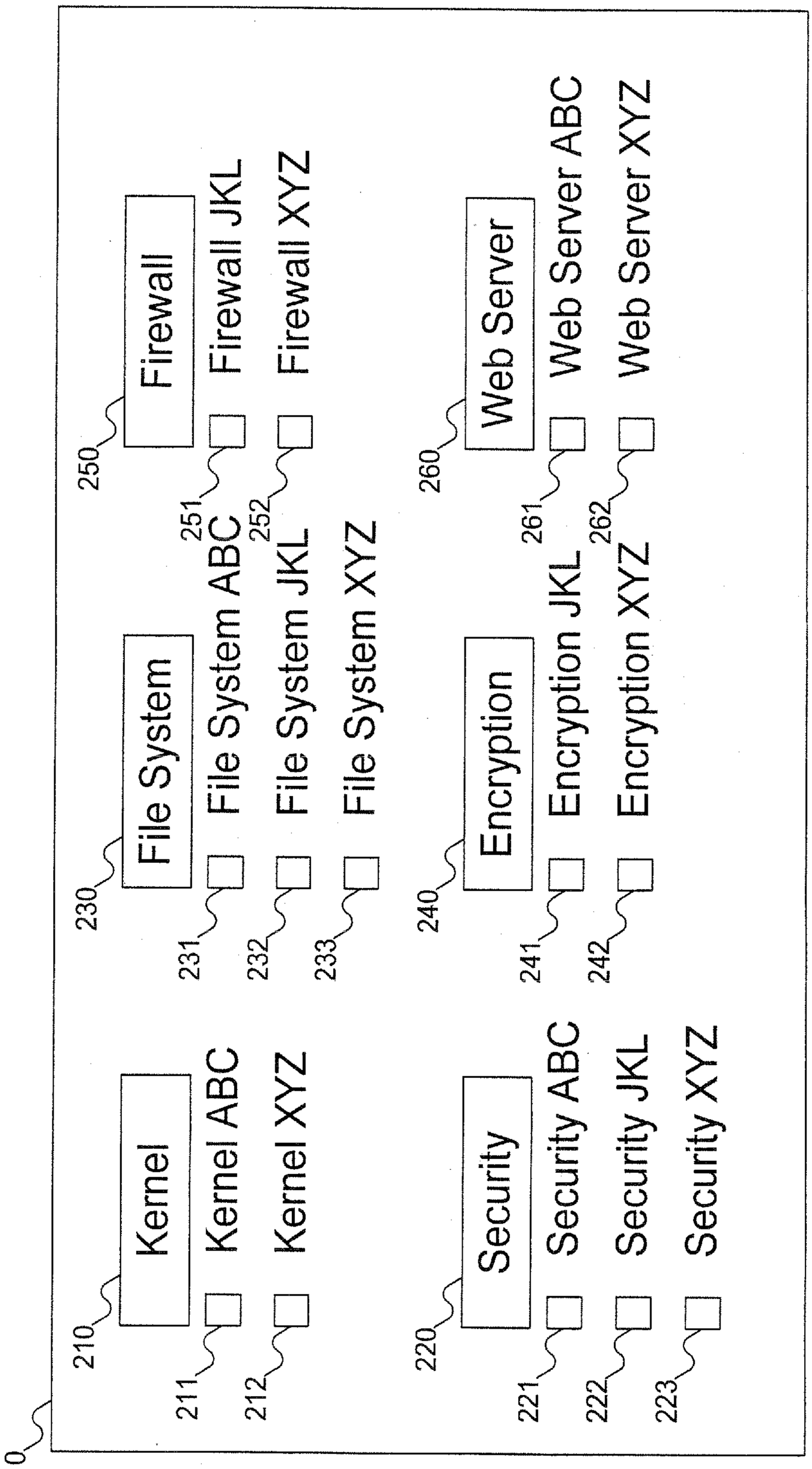
110
210
Kernel
211
Kernel ABC
212
Kernel XYZ
220
Security
221
Security ABC
222
Security JKL
223
Security XYZ
230
File System
231
File System ABC
232
File System JKL
233
File System XYZ
240
Encryption
241
Encryption JKL
242
Encryption XYZ
250
Firewall
Firewall JKL
Firewall XYZ
260
Web Server
Web Server ABC
Web Server XYZ

FIG. 2

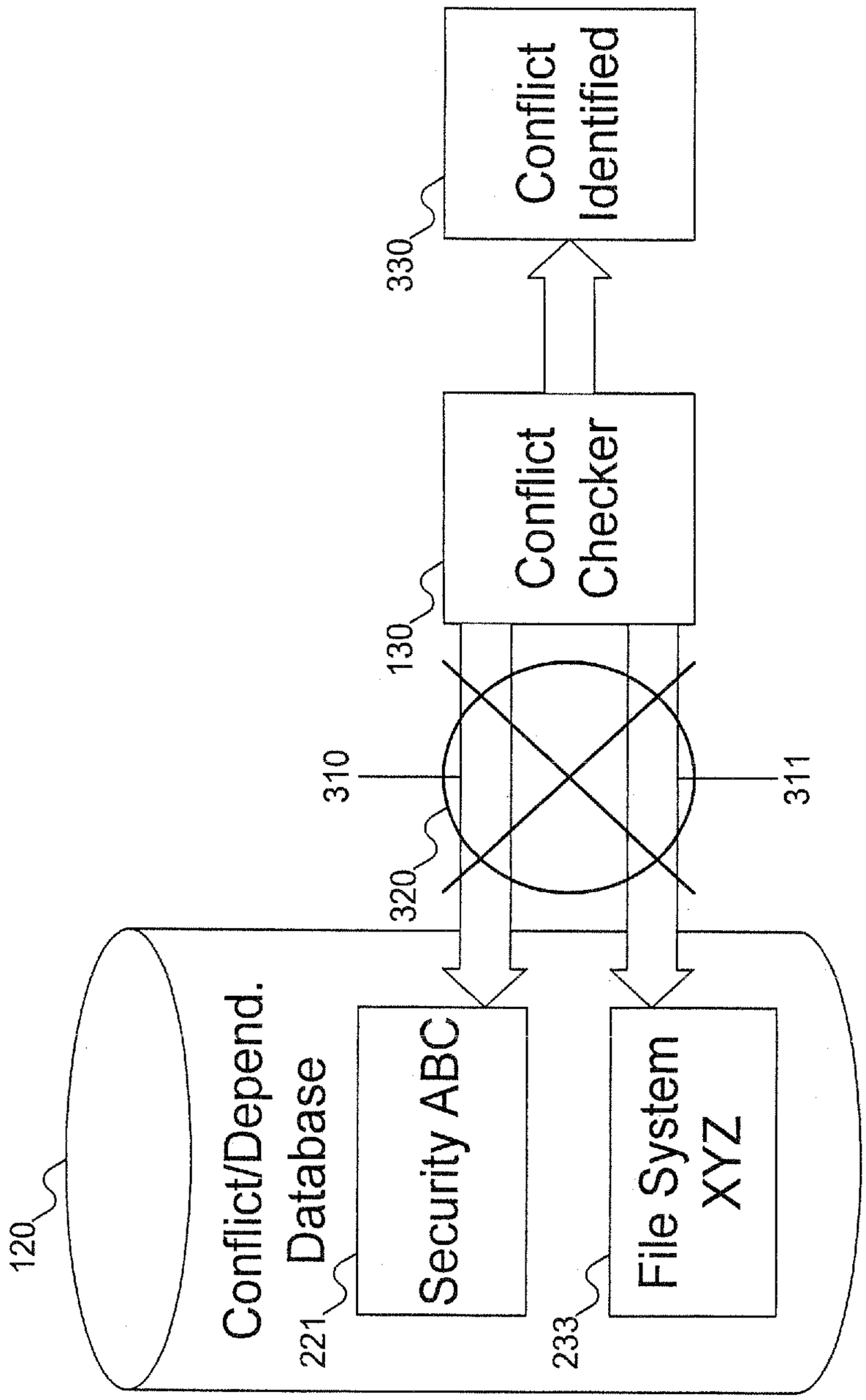
Conflict Identified
330
Conflict Checker
130
310
311
320
Conflict/Dependency Database
120
Security ABC
221
File System XYZ
233

FIG. 3

120	420	421	423	423	424
	Kernel XYZ	Security ABC	File System XYZ	Encryption MNO	Mail Server ABC
410 Kernel XYZ		X 430			
411 Security ABC	X		X 432		X 434
412 File System XYZ		X 433			
413 Encryption MNO				X 435	
414 Mail Server ABC					

FIG. 4

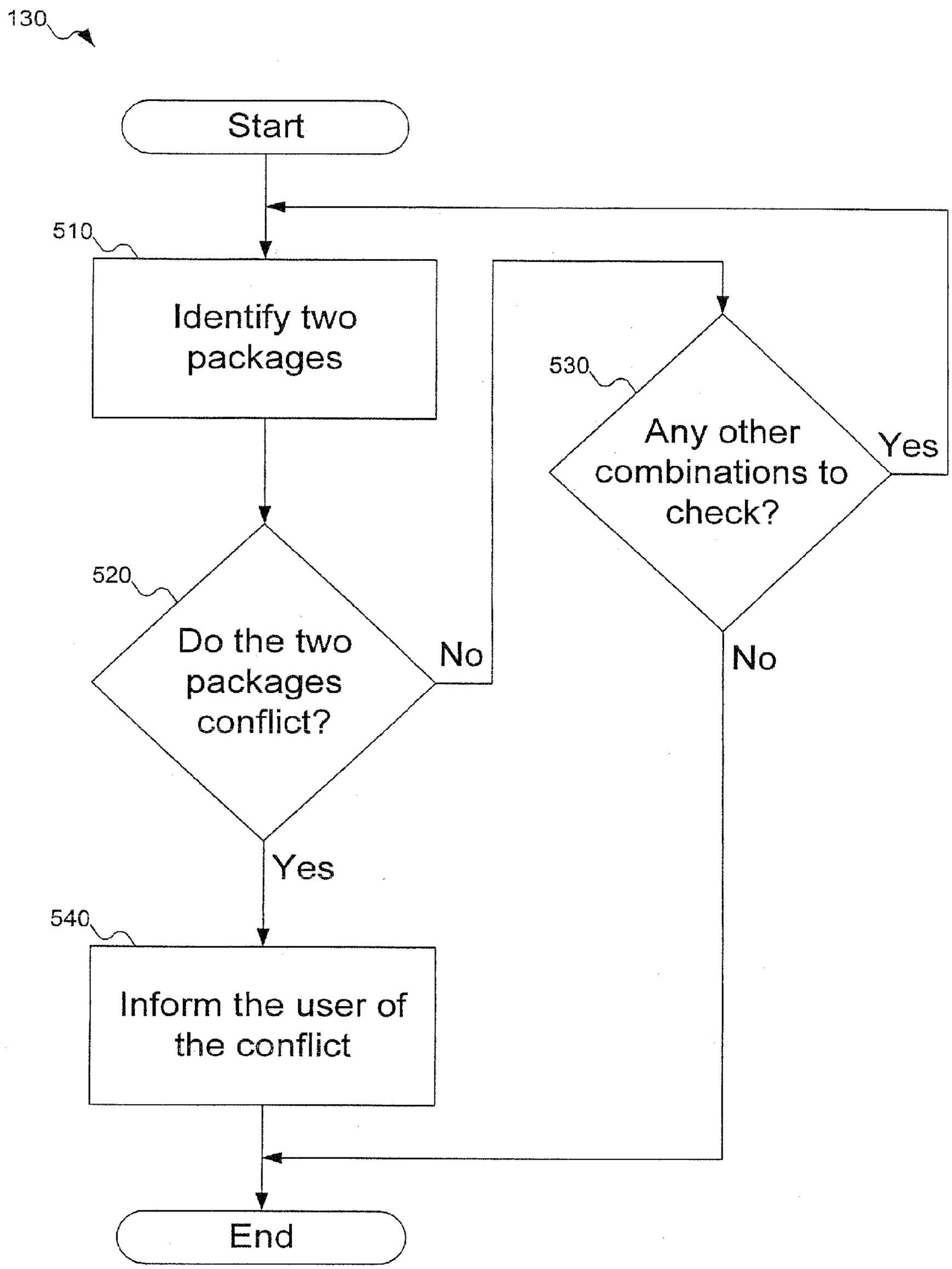
130
Start
510
Identify two packages
520
Do the two packages conflict?
No
Yes
530
Any other combinations to check?
Yes
No
540
Inform the user of the conflict
End

FIG. 5

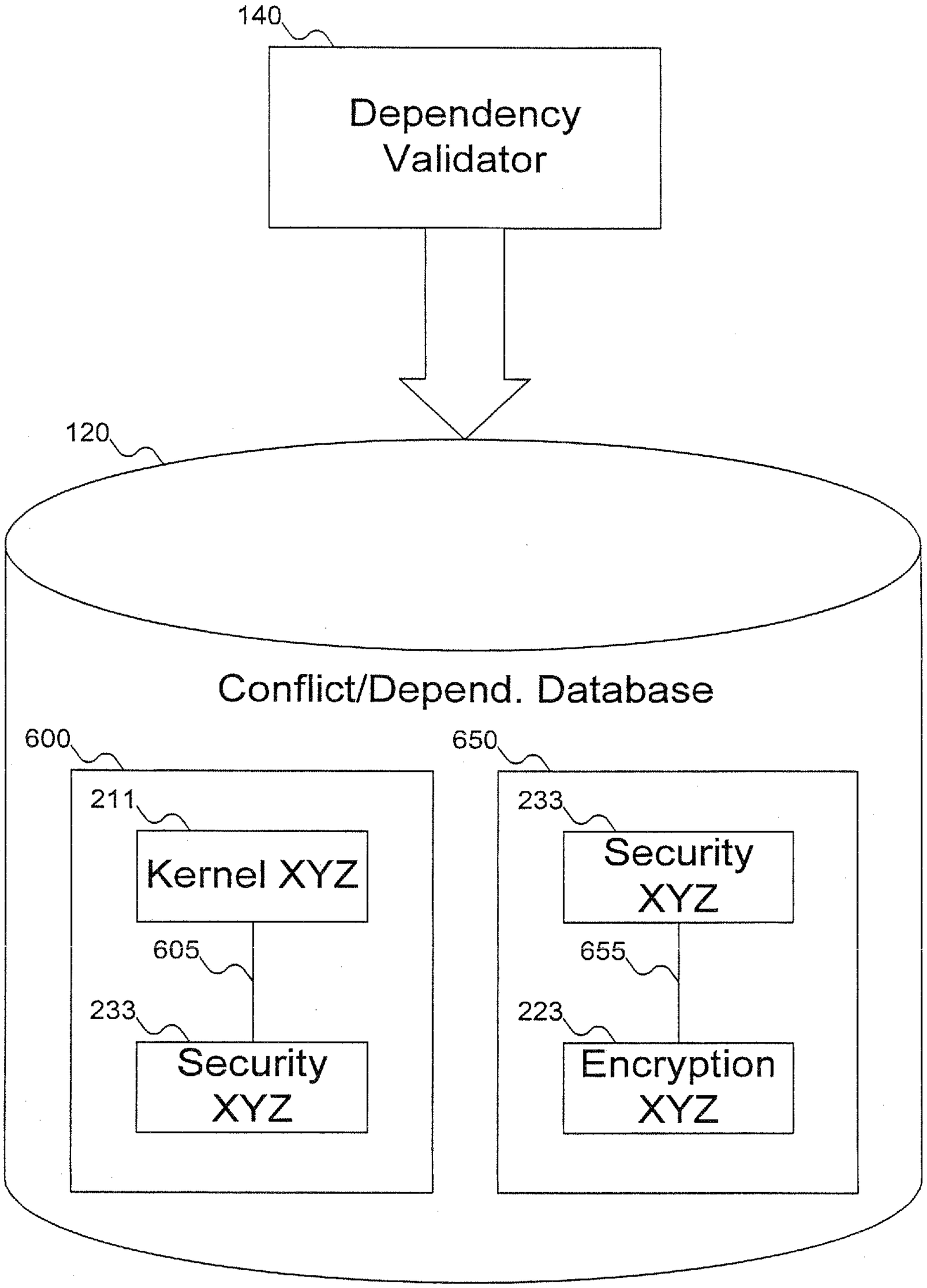
140
Dependency Validator
120
Conflict/Depend. Database
600
211
Kernel XYZ
605
233
Security XYZ
650
233
Security XYZ
655
223
Encryption XYZ

FIG. 6

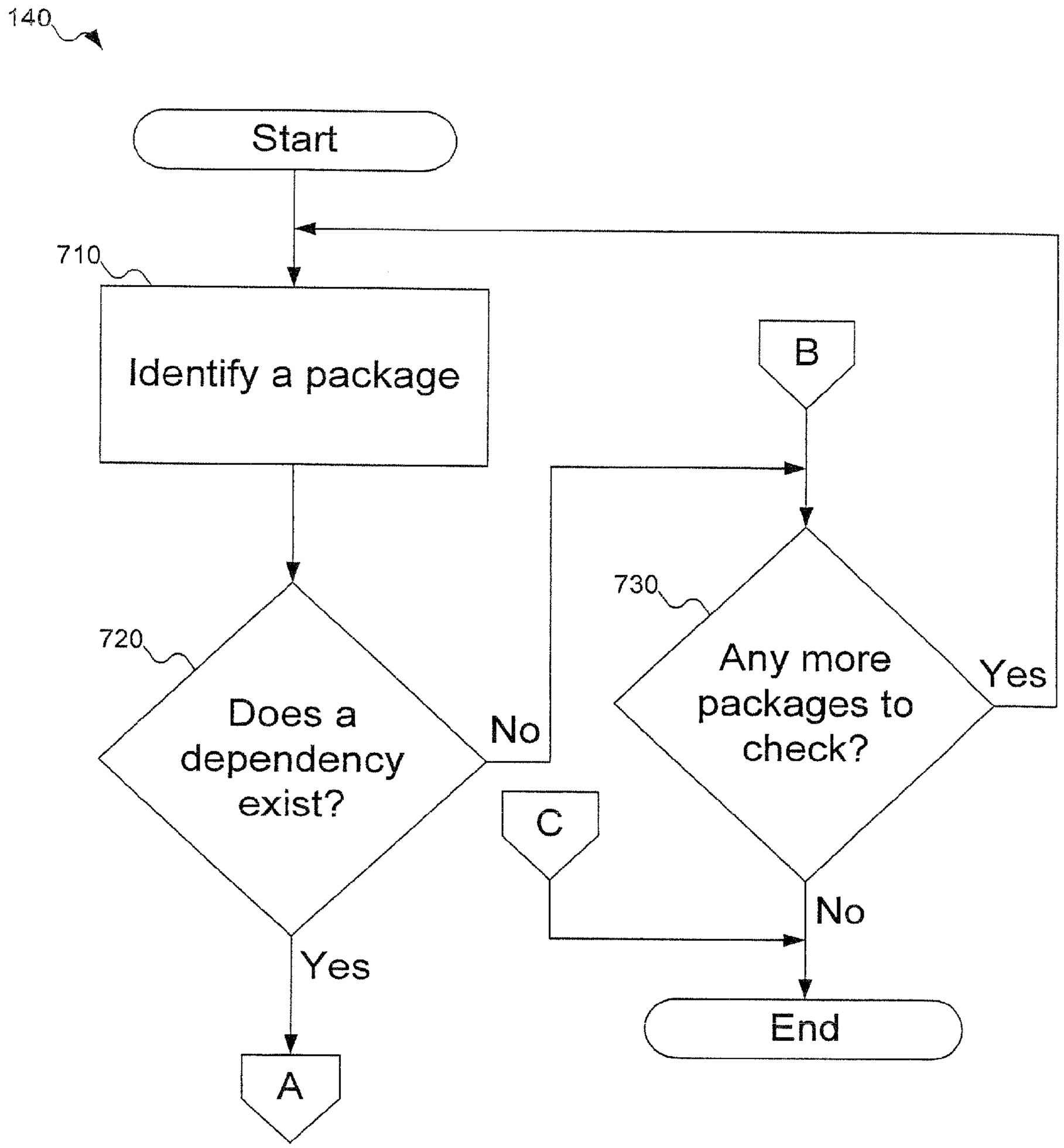
140
Start
710
Identify a package
720
Does a dependency exist?
No
Yes
A
B
730
Any more packages to check?
Yes
No
C
End

FIG. 7A

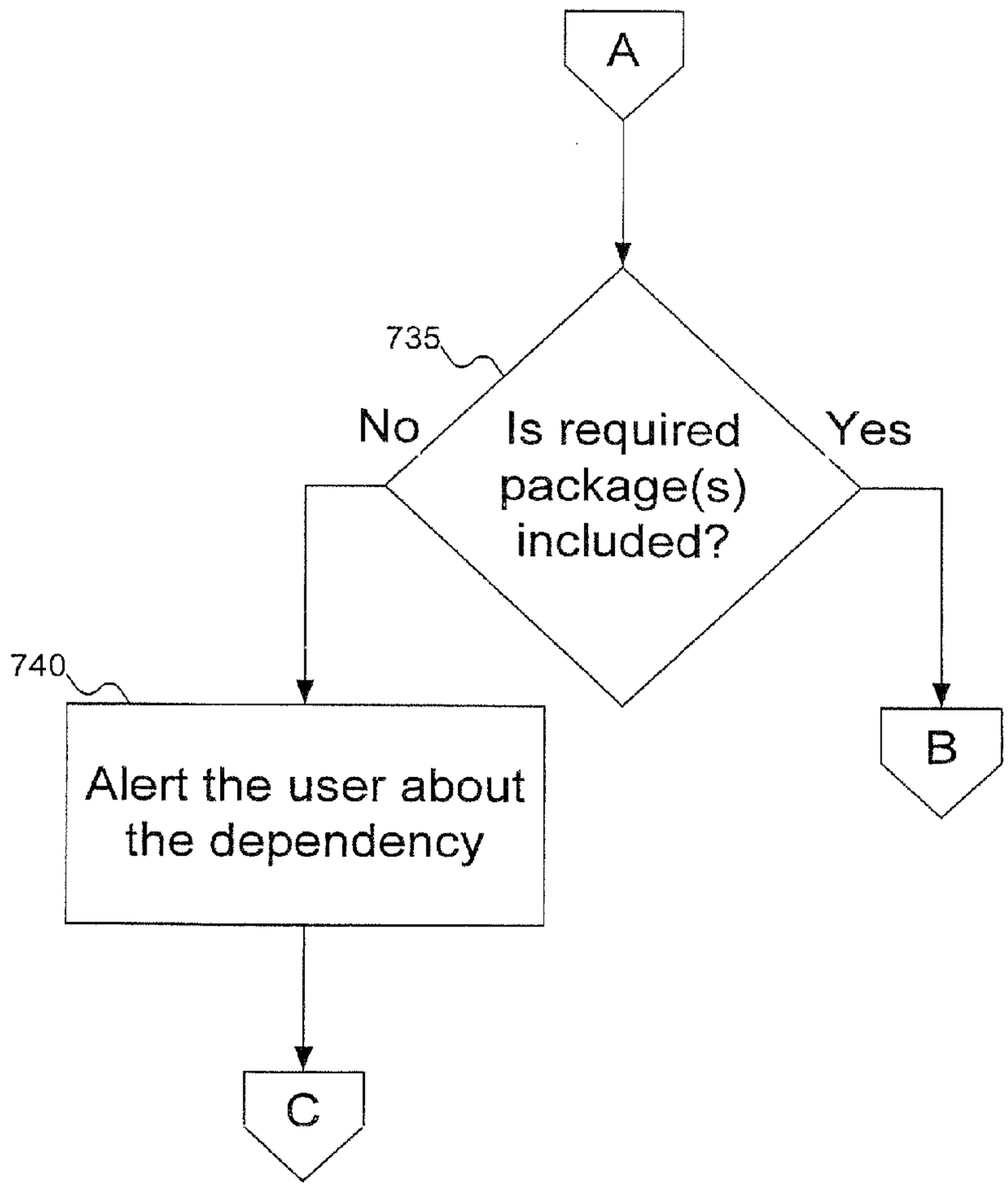
A
735
Is required package(s) included?
No
Yes
740
Alert the user about the dependency
B
C

FIG. 7B

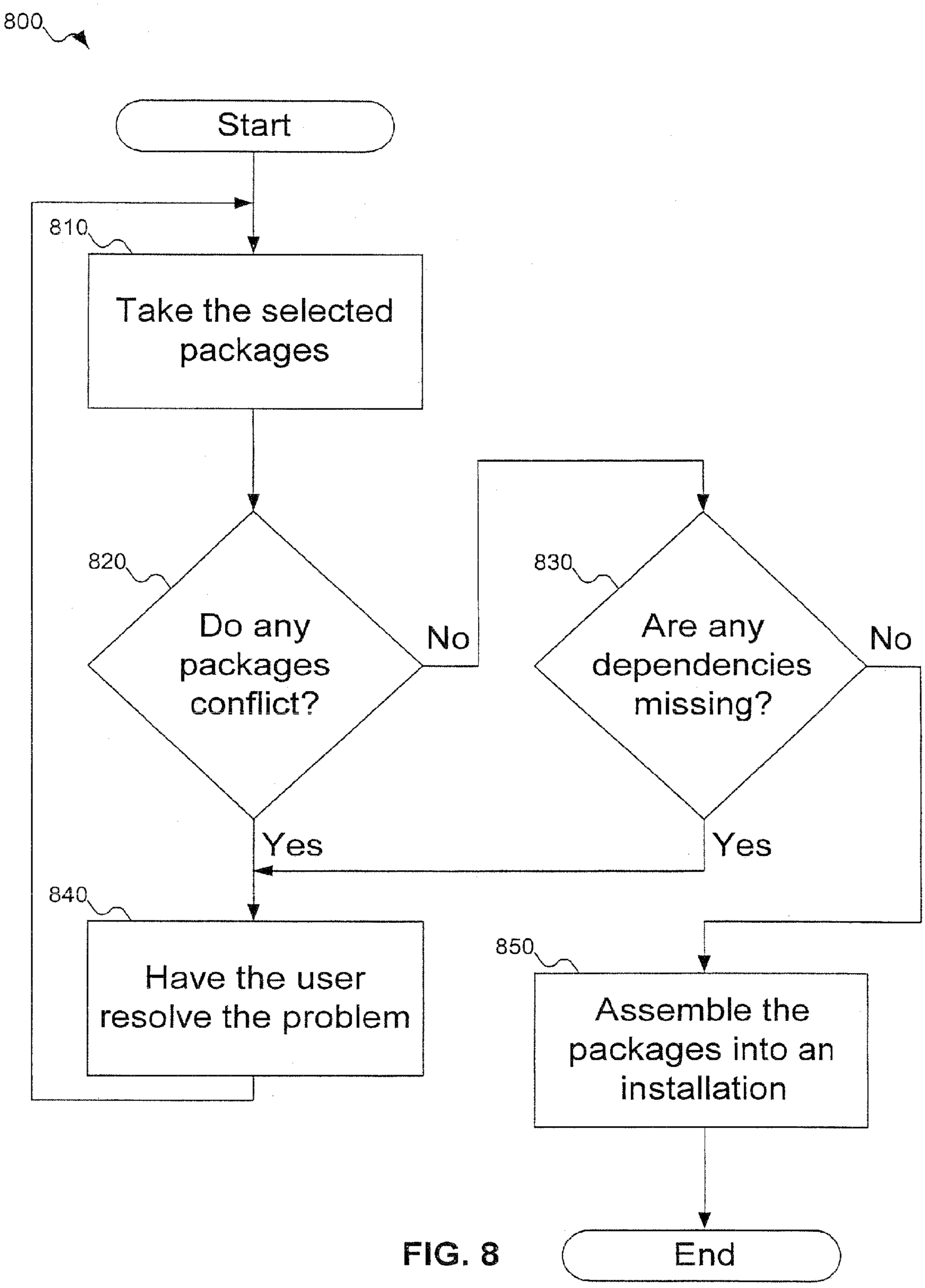
800
Start
810
Take the selected packages
820
Do any packages conflict?
No
Yes
830
Are any dependencies missing?
No
Yes
840
Have the user resolve the problem
850
Assemble the packages into an installation
End

FIG. 8

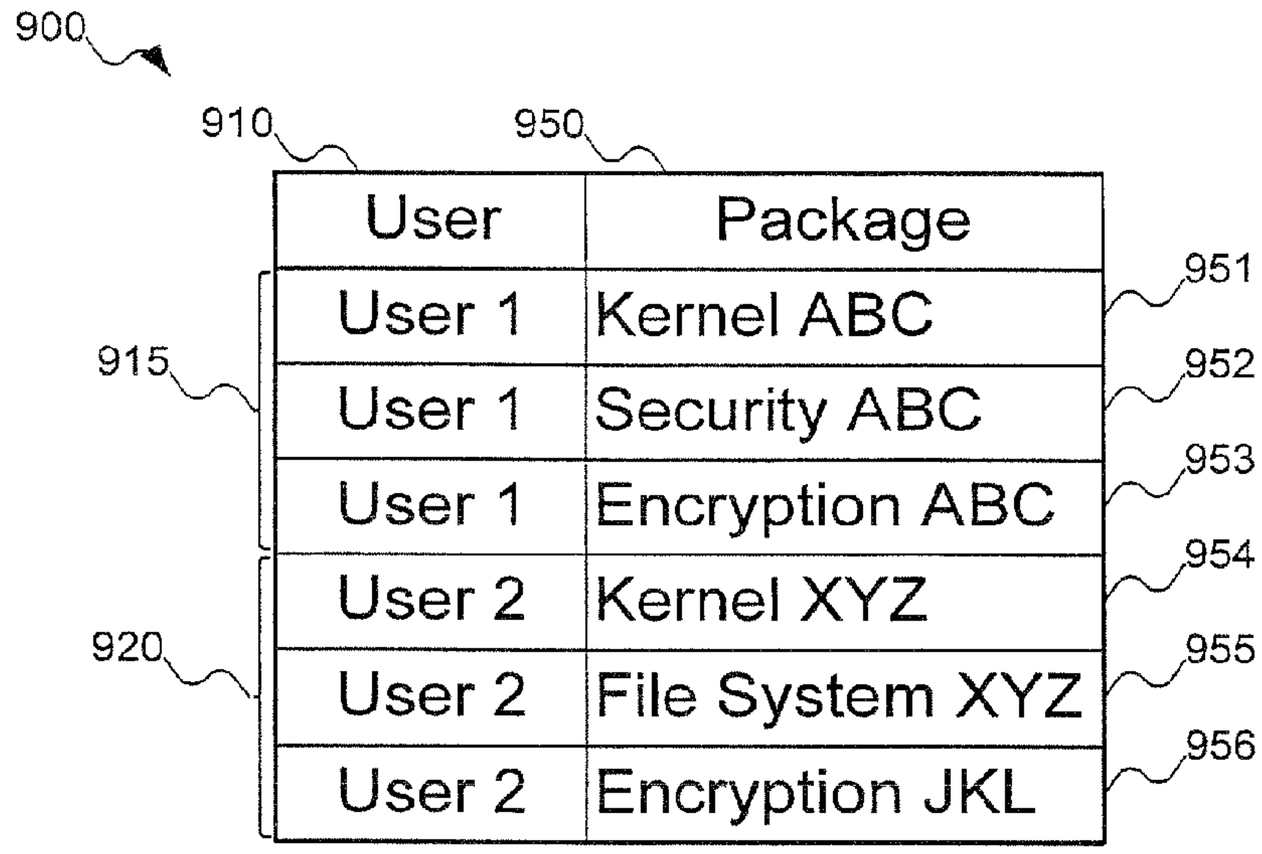
900
910
950
User
Package
User 1
Kernel ABC
951
915
User 1
Security ABC
952
User 1
Encryption ABC
953
User 2
Kernel XYZ
954
920
User 2
File System XYZ
955
User 2
Encryption JKL
956

FIG. 9

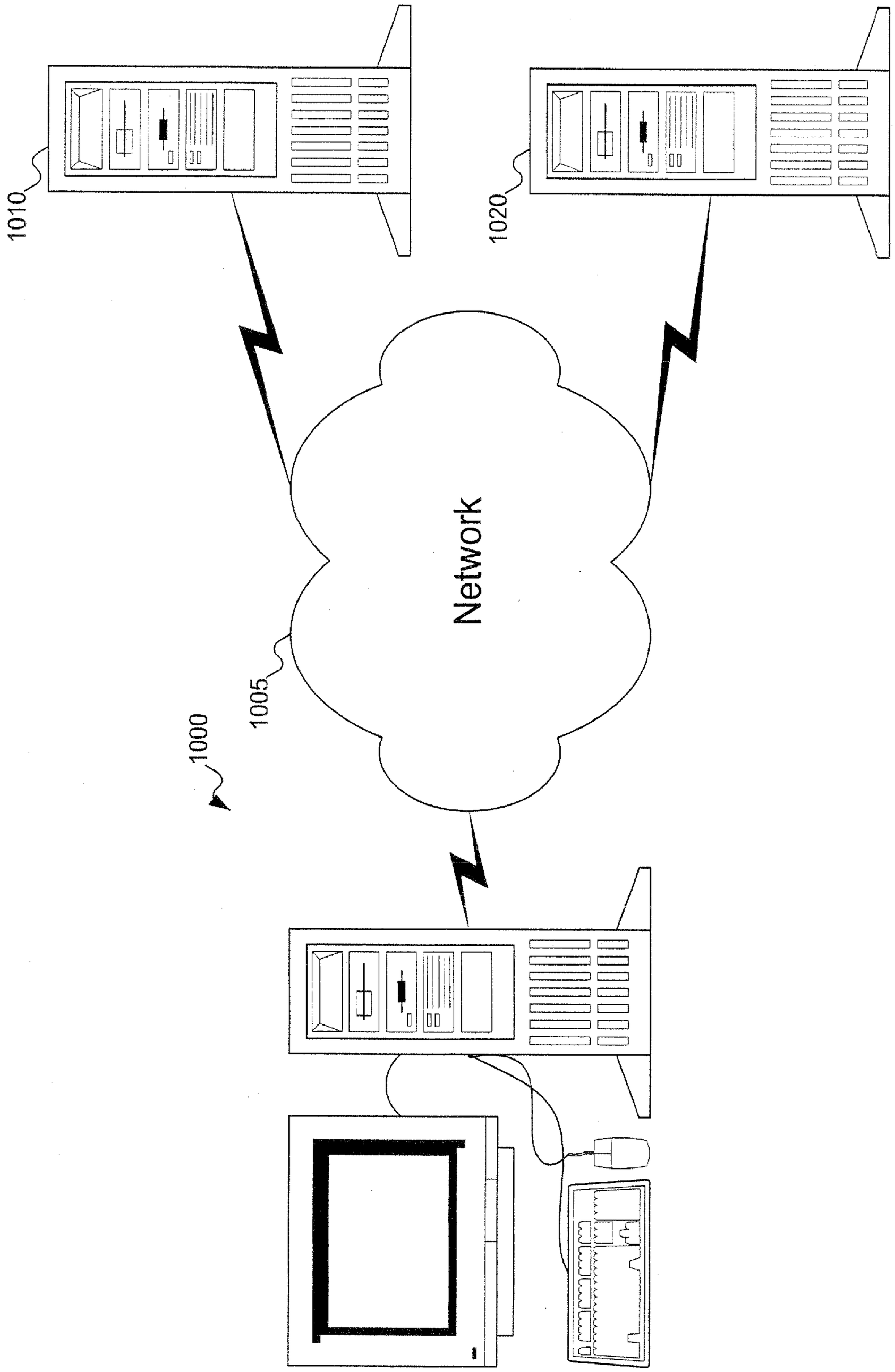

FIG. 10

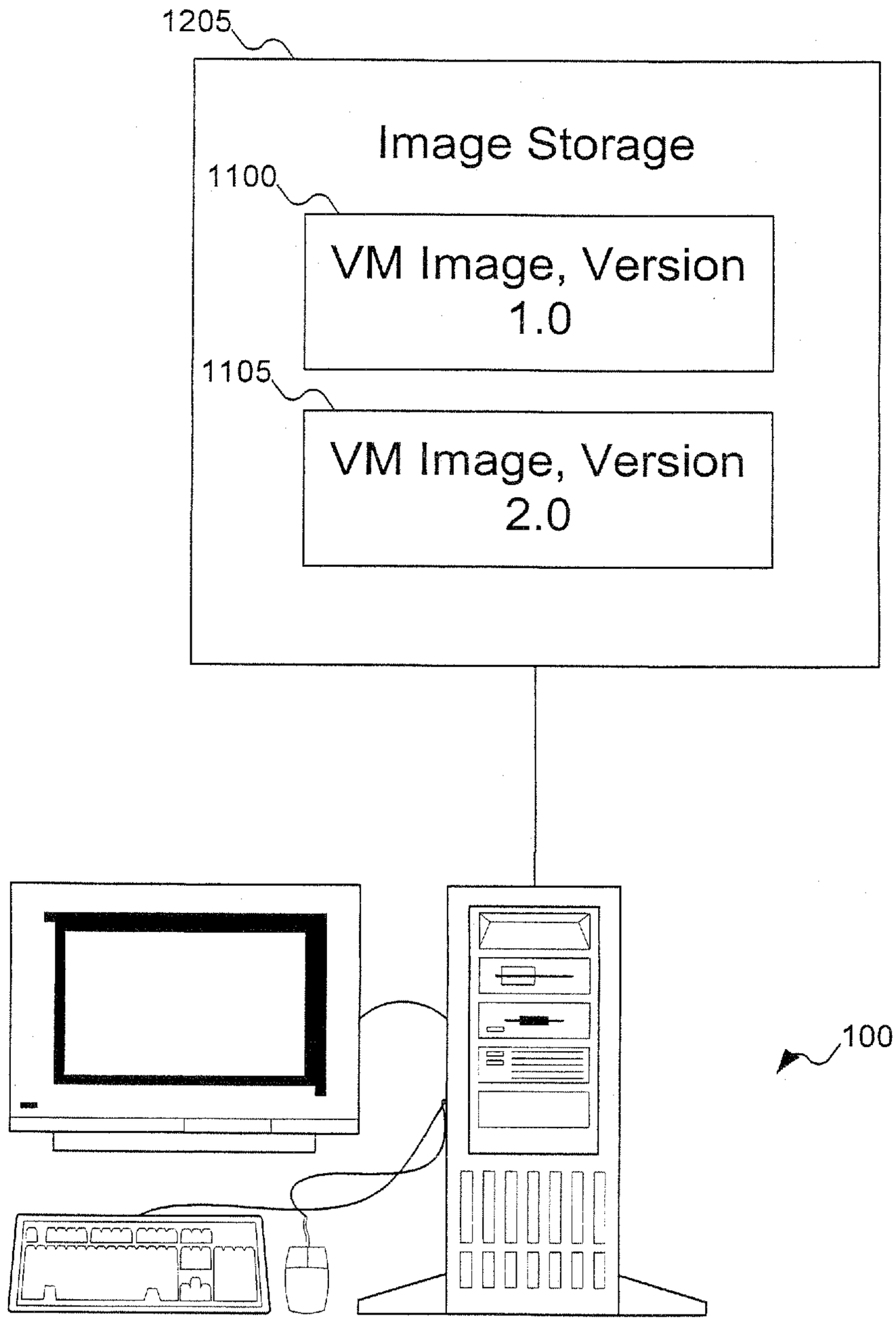
1205
Image Storage
1100
VM Image, Version 1.0
1105
VM Image, Version 2.0
100

FIG. 11

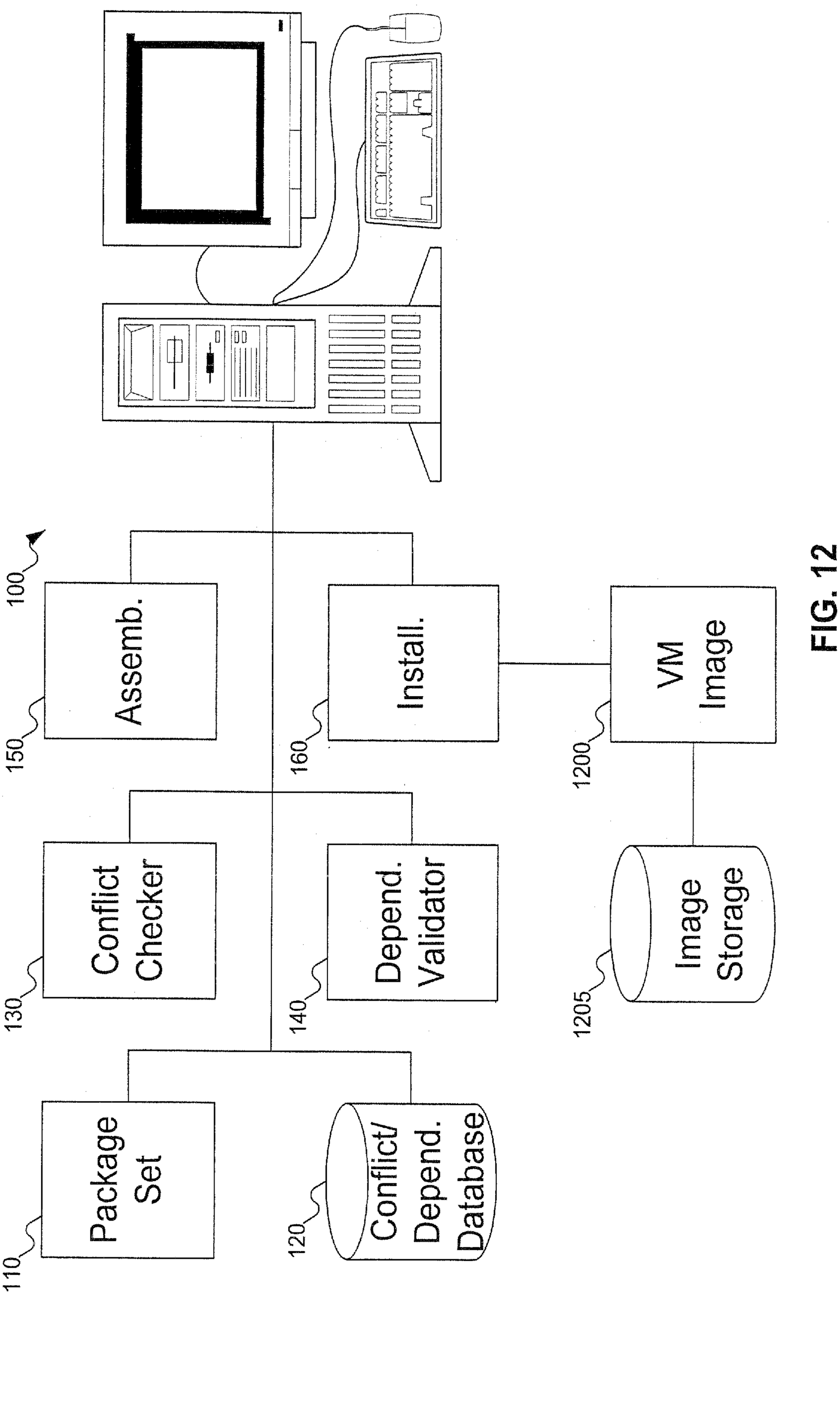
100
Assemb.
150
Install.
160
VM Image
1200
Conflict Checker
130
Depend. Validator
140
Image Storage
1205
Package Set
110
Conflict/ Depend. Database
120

FIG. 12

SYSTEM AND METHOD FOR CREATING A CUSTOMIZED INSTALLATION ON DEMAND

RELATED APPLICATION DATA

This application claims is a continuation-in-part of, commonly assigned, U.S. patent application Ser. No. 11/134,541, titled "SYSTEM FOR CREATING A CUSTOMIZED SOFTWARE INSTALLATION ON DEMAND," filed May 19, 2005 by the same inventor, now U.S. Pat. No. 8,074,214, issued Dec. 6, 2011, and is hereby incorporated by reference.

FIELD OF THE INVENTION

This invention pertains to allowing a user to create a customized virtual machine image, and more particularly to enabling users to select and verify the interoperability at run-time, of a virtual machine image.

BACKGROUND OF THE INVENTION

Software distributions are typically built into an installation program and stored on a compact disc (CD), to be purchased by a customer. Such distributions usually include at least one program file and a number of other packages that work with the program file to provide additional functionality and features. These CDs are prepackaged and designed to include features that the company selling the software thinks will be desired by customers.

Manufacturers of such software products recognize that a "one size fits all" mentality often does not work for all clients. Thus, manufacturers sometimes produce multiple different versions of a software package that a user chooses from. Applications that are individually selected are then individually installed. If several different applications are selected, a considerable amount of time can be spent installing the different applications. In addition, after installation, each application then must be individually configured as desired by the user.

To make it easier for users wishing to install several applications a vendor can bundle several applications together in an application suite. For example, application suites are very popular products today. Most versions include a word processor and a spreadsheet program. But some versions might include a database package, whereas other versions might include a slideshow generating program. Still other versions might include stripped-down versions of the products, priced to sell to students and educators. By offering different versions of the product, the manufacturer hopes that as many customers as possible will be satisfied by the different versions, thereby maximizing the manufacturer's sales.

This approach to building pre-packaged software installations is used not just with application software, but also with operating systems. For example, in selecting a Linux® distribution, a customer must choose between different packages of distributions that have been released and are available in off-the shelf combinations. (Linux is a registered trademark of Linus Torvalds.) A customer typically chooses a Linux distribution by first selecting a vendor who sells Linux distributions, and then identifying a particular distribution available from the vendor that has the most features that the customer is looking for. But if a customer wants a finer level of control in selecting the structure of the Linux distribution, the customer is usually left wanting.

Virtual machine (VM) images of a Linux distribution are handled similarly. Virtual machines enable multiple operating systems to be run on a computer at the same time: in other words, the multiple operating systems can be run in parallel. A VM consists of a hosting operating system (OS) and VM images representing operating systems to run on the computer. The hosting OS loads the appropriate VM images. Each VM image is essentially an emulation of the OS it represents, appearing to the user as if the OS were running directly on the computer. As a VM image is installed on a computer, the VM image is then configured to access installed hardware, use partitions of a hard drive, and use optional features of the VM image. Customers looking for a VM image are hindered by the limitations discussed above. Namely, a customer must first select a vendor selling VM images, and then identify a VM image that has the most features that the user desires.

Accordingly, a need remains to allow a user to create a customized VM image, including only operating system packages and applications that the user wants, verifying that the VM image will be operable at run-time, and including any required package dependencies.

SUMMARY OF THE INVENTION

A customized virtual machine image is created by allowing a user to select packages that the user is interested in installing as a virtual machine image. During the process, the user is informed if the selected packages will not be interoperable with each other at run-time. The user is then given an opportunity to resolve the conflict. In cases where packages conflict or will not work together at run-time, a different set of packages can be selected to serve the purpose. After verifying that the selected packages do not conflict, the user then can then deploy the customized virtual machine image.

The foregoing and other features, objects, and advantages of the invention will become more readily apparent from the following detailed description, which proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a system on a computer configured to support a distribution of Linux on demand, according to an embodiment of the invention.

FIG. **2** shows an example of the set of packages of FIG. **1** that are available for user selection.

FIG. **3** shows an example of two packages from the database of run-time conflict information of FIG. **1** that will conflict at run-time.

FIG. **4** shows an example table in the database of package run-time conflicts of FIG. **1**.

FIG. **5** shows a flowchart of the procedure used by the conflict checker of FIG. **1** to resolve conflicts in packages.

FIG. **6** shows an example of dependency information that is stored in the database of FIG. **1**.

FIGS. **7**A-**7**B show a flowchart of the procedure used by the dependency validator of FIG. **1** to validate that the necessary package dependencies are included in the customized installation.

FIG. **8** shows a flowchart of the procedure used by the assembler of FIG. **1**, to assemble an installation with both dependency package validation and conflict resolution for all packages in the installation.

FIG. **9** shows a table identifying what packages a particular user received in the installation of FIG. **1**.

FIG. **10** shows a system where the computer of FIG. **1** is a bootstrap server capable of installing the installation on to remote servers.

FIG. **11** shows the image storage of FIG. **12** storing two versions of a VM image.

FIG. **12** shows the computer system of FIG. **1** configured to support a virtual machine (VM) image and image storage, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows a system on a computer with a set of available packages, a set of user requirements, a database with dependency and run-time conflict information, a conflict checker, a dependency validator, an assembler to assemble a customized installation, an installation, and a backup ISO image of the installation according to an embodiment of the invention. Computer **100** includes all the typical elements of a computer, such as a central processor, memory, bus, disk space, etc. Also, computer **100** can be accessed locally by the user, or remotely over a network, such as a LAN, WAN, the Internet, etc., which can be reached via either a wired or a wireless (such as IEEE 802.11a/b/g/n, among others) connection.

Available on computer **100** is a set of, for example, Linux packages **110** available for the customized installation. The set of Linux packages **110** can be packages that have been developed for Linux and are available to Linux users. The packages in package set **110** can include, for example, versions of the Linux kernel, as well as other software by developers from all over the world. The packages can either be open source or closed source, but typically the packages are compiled modules, rather than source software that the user has to then build into an executable module. Each of these packages is designed to address a particular aspect of the installation. For instance, in one embodiment of the invention there could be a package that involves computer security or that acts as a mail server. Typically, the set of Linux packages **110** is distributed as a compact disc (CD), but a person skilled in the art will recognize that the set of Linux packages **110** could be distributed in other manners: for example, by being available for download from a website across a network.

Giving users control over the packages that go into a Linux installation introduces complexities that can prevent the Linux system from running properly. For example, packages must be interoperable at run-time, meaning that no packages in the installation have conflicts. Also, if any packages in the installation have dependencies, then those dependencies must also be included in the installation in order for the Linux system to function properly. Embodiments of the invention are designed to ensure that these issues are properly addressed.

In an embodiment of the invention, some packages in the set of the packages **110** can be designed to operate by themselves (other than needing the kernel). There can also be packages that are to be used in conjunction with one or more other packages. In some cases, the two packages provide features that complement one another. In other cases, one of the packages is a primary package that the secondary package depends on. In these second cases, there is a dependency between the primary package and the secondary package. If an installation includes the secondary package but not the primary package, the secondary package might not operate properly (if it operates at all). Thus, dependencies are a concern that needs to be addressed and are described in greater detail below.

In addition, some packages in the set of packages **110** might not be compatible with other packages. In other words, these packages conflict; they are not interoperable at run-time. While one or the other of the packages can work at run-time, both might not. Users installing a customized Linux installation obviously would expect that all the packages built into the installation will run. Thus, conflicts are a concern that needs to be addressed.

To solve these problems, computer **100** includes database **120** that stores conflict and dependency information, making it possible to verify that no packages will conflict at run-time and that all required dependencies will be included.

Computer **100** also includes a conflict checker **130** to ensure that none of the selected packages will conflict at run-time, and a dependency validator **140** to validate that all dependencies of selected packages are also selected. Once the Linux packages have been selected and checked for conflicts and dependencies, an assembler **150** can then assemble the selected packages into an installation **160**. In one embodiment of the invention, the assembler assembles the installation **160** as an ISO image file **170**. All of these elements are discussed in greater detail below.

FIG. **12** shows the computer system of FIG. **1** configured to support a virtual machine (VM) image distribution on demand and image storage, according to another embodiment of the invention. In this embodiment, the assembler assembles installation **160** as virtual machine (VM) image **1200**, capable of running on a computer with an appropriate hosting operating system. VM image **1200** typically includes the custom built installation including a virtual operating system. In an embodiment of the invention VM image **1200** also includes selected applications to run on the virtual operating system represented in VM image **1200**.

An advantage to distributing installation **160** as VM image **1200** is that in addition to including a selected operating system with selected packages that are operable at run-time, other software applications can be included on VM image **1200**. Including applications on the VM image means that once VM image **1200** is installed on a computer, each additional application is also installed on the computer. One installation for several different applications means that a user selecting software for a large number of computers can save time by installing customized VM image **1200**.

In an embodiment of the invention, after assembling the selected packages into VM image **1200**, VM image **1200** can be deployed on a development computer for configuration. For example, configuring VM image **1200** can include changing operating system settings and/or application settings. In an embodiment of the invention, testing VM image **1200** can also be performed on the development computer, although testing is typically unnecessary because verification occurs with conflict checker **130** and dependency validator **140**.

Once VM image **1200** has been assembled and configured, VM image **1200** can be deployed on a production computer. VM image **1200** can also be stored in image storage **1205**. In FIG. **12**, image storage **1205** stores VM image **1200** and metadata about VM image **1200**. For example, image storage **1205** can include comments for notes on the image. The metadata in image storage **1205** can include an owner of the image, the date the image was assembled, a version of the image, deployment information, etc. A person skilled in the art will recognize that there is other metadata that can be included in image storage **1205**. Image storage **1205** is discussed in greater detail below with reference to FIG. **11**.

FIG. **2** shows an example of a set of packages **110** in FIG. **1** that are available for selection, according to an embodiment of the invention. In the example set of packages **110**, there are six package categories, kernel **210**, security **220**, file system **230**, encryption **240**, firewall **250** and web server **260**, as well as two to three packages for each category. While the present embodiment has only six categories and fourteen packages, a person skilled in the art will recognize that the categories are

not required. In addition, the set of packages can be organized into any number of categories, and any number of packages per category (and, of course, any number of total packages).

In an embodiment of the invention, a deployment tool can be used to investigate the computer environment of the user. The selection of the packages can be done automatically for the user based on the packages that are in the user's current Linux system. After the deployment tool has identified what packages are currently on the user's system, an installation is built using the most recent versions of those packages (along with any other packages necessary or deemed of interest).

In another embodiment, a user of the system will be familiar with Linux and its respective packages, and will have preferences on which packages he is interested in installing. For example, a user might be particularly interested in getting the security package XYZ, as well as the encryption package XYZ. With the checkbox embodiment of FIG. **2**, the user would select a kernel of his choice, kernel ABC **211** or kernel XYZ **212**, and then also select security XYZ **223**, and encryption XYZ **242**. And finally in another embodiment, a user might not be interested in security, but might need a file system **230**, a web server **260**, and a firewall **250**. Again, the user likely has particular packages in mind, and can select the appropriate packages. But if the user has no particular preferences for certain features, the system can provide default selections, or make recommendations on those features (based, for example, on levels of compatibility among the various user-selected packages). While checkboxes are the user interface element used in the example of FIG. **2**, a person skilled in the art will recognize that there are other means of identifying selected packages for an installation, e.g., list box, search boxes, etc.

In an embodiment of the invention, the packages that are built into an installation are compiled binary files that the user will be able to run immediately after installing the installation. In the prior art, customers built installations by compiling source code components from different vendors. Because compiler settings can affect the behavior of software, even technically skilled users could inadvertently build an installation that would not work as intended. By providing the user with compiled modules, embodiments of the invention avoid these problems, and save the user time (in that the user does not have to spend time building the installation from the source code).

In an embodiment of the invention, the image is assembled with each software package as if the package had been installed on a computer directly. Then, the image need only be copied on to a target computer with a hosting OS in order to use the software included in the image.

In the prior art, each software package would be directly installed and then configured on a target computer. Further, if the distribution were intended for more than one target computer, each software package would be individually installed on each computer. Installing a selected set of software packages on a computer would mean that the computer would not be available for user by a user for some period of time.

But in an embodiment of the invention, assembling a distribution as a VM image enables a user to bypass off-line installation of each individual package, and instead simply copy the image onto a computer with a hosting OS (requiring less time). Another benefit from this embodiment is that if there are multiple computers to receive the same distribution, each of these computers simply receives a copy of the VM image as assembled and configured. An embodiment of the invention also enables a user who has either changed the configuration of his VM image or has otherwise corrupted the VM image to easily copy the VM image as it was initially assembled and configured.

FIG. **3** shows an example of the conflict checker of FIG. **1** identifying two packages that will conflict at run-time using the database of run-time conflict information in FIG. **1**, according to an embodiment of the invention. In FIG. **3**, the installation includes packages "security ABC" **221** and "file system XYZ" **233**. The conflict checker **130** obtains information about the security ABC package **221** from conflict database **120** with locator **310**, and information about file system XYZ package **233** from conflict database **120** with locator **311** (which can, of course, be the same locator). In the example shown in FIG. **3**, conflict checker **130** determines that the packages conflict, represented by conflict symbol **320**, and presents message **330** to the user, so that the conflict can be resolved.

In another embodiment, the selected packages might be packages that do not conflict at run-time. In this case, the conflict checker **320** does not prompt the user to resolve the package conflict, and instead compares the other packages in the set of selected packages in search of conflicts. FIG. **4** shows an example database table in the database in FIG. **1** that records packages that conflict at run-time, according to an embodiment of the invention. Table **120** is a table with rows **410-414** and columns **420-424** representing the various packages, such as Kernel XYZ **410**. In the example shown in FIG. **4**, there is only conflict information for five packages, but a person skilled in the art will recognize that in other examples there can be any number of packages.

Conflict information is represented by an X, such as Xs **430**, **431**, **432**, **433**, **434**, **435**, in entries in table **200**. For each pair of packages that has a conflict, table **200** stores an indication of this conflict in the appropriate table entry. For example, X **430** represents a conflict between package "security ABC" in column **221** and package "kernel XYZ" in row **210**. The conflict **430** means that an installation containing both kernel XYZ and security ABC will not be interoperable at run-time. In other words, while the kernel XYZ package can operate on its own, and can interoperate with other packages, kernel XYZ does not interoperate with security ABC at run-time. (Presumably, there is some other version of the kernel that interoperates with security ABC, or else security ABC cannot be used at all.)

Although FIG. **4** shows conflict information being arranged in an N×N table, where N is the total number of packages, a person skilled in the art will recognize that there are other ways of recording conflict information. For example, database **120** includes redundant information, in that every combination of packages is represented twice, e.g., Xs **430** and **431** both represent a conflict between kernel XYZ and security ABC. Other embodiments of the conflict information can include linked lists, arrays, etc. In addition, a person skilled in the art will recognize that other conflict combinations are possible, and will recognize how to modify database **120** to store this additional information. For example, there may be three different packages, which include no pair-wise conflicts, but as a trio conflict.

FIG. **5** shows a flowchart that the conflict checker **130** in FIG. **1** uses to resolve run-time conflicts in packages, according to an embodiment of the invention. In step **510**, the conflict checker starts by identifying two of the packages that have been selected for the installation. In step **520**, the conflict checker refers to the database to see if the packages have a run-time conflict. This can be accomplished, among other ways, by having the database store, for each package, a list of other packages with which the first package conflicts. A per-

son skilled in the art will recognize that this information can be stored in a number of different manners: for example, by using a list for each package, or by creating a table showing pairs of packages and flagging which combinations have conflicts. (A person skilled in the art will also recognize that conflicts can extend beyond pairs of packages: for example, there can be three packages which do not pair-wise conflict, but as a trio conflict.) If there is a conflict with the packages, the user is alerted with a message at step **540**. Otherwise, at step **530** the conflict checker looks to see if there is another combination of packages to check. If there are no more combinations, the conflict checker finishes, having successfully validated that no selected packages contain any run-time conflicts. If there are more combinations of selected packages, the conflict checker **130** then goes back to step **510** and begins the process all over again. FIG. **5** is described in an abstract model (for example, FIG. **5** does not specify exactly how the conflict checker selects packages in step **510**). But a person skilled in the art will recognize how to adapt FIG. **5**: for example, by using nested loops to select pairs of packages. A person skilled in the art will also recognize how to adapt FIG. **5** to check for conflicts among groups of packages larger than two.

In an embodiment of the invention, the conflict checker analyzes all combinations of packages before alerting users of existing run-time conflicts. The system then notifies the user as to which packages had conflicts, and prompts the user to make a different selection of packages that do not conflict at run-time. When the user has made a different selection, the conflict checker again checks to see if the new selection of packages has introduced any new conflicts between packages.

In another embodiment of the invention, the conflict checker can provide the user with a recommendation for resolving the current run-time conflict. Sometimes a conflict between packages might have a relatively straightforward resolution. For example, there might be one package that conflicts with several others. If those other packages do not conflict with any more packages, then the system could recommend an alternative package to the one that is causing the numerous conflicts.

In yet another embodiment, a means of resolving a package conflict might not be as straightforward. For example, it could be the case that two packages conflict with each other, but not with any other packages in the set of selected packages. In this case, it is not necessarily clear which of the two conflicting packages should be replaced with an alternative non-conflicting package. In this case, the conflict checker can at least alert the user to which packages are in conflict.

FIG. **6** shows an example of dependency information that is stored in database **120** in FIG. **1**, according to an embodiment of the invention. In the present embodiment, two dependencies are shown. In dependency **650**, Encryption XYZ **223** has a package dependency of Security XYZ **223**. So if Encryption XYZ **223** is in the installation, then Security XYZ **223** should also be included in the installation for the encryption software to run.

Similarly, dependency **600** shows that Security XYZ **233** requires that Kernel XYZ **211** be selected and included in the installation. As a result, a selection of Encryption XYZ **223** will require that not only Security XYZ **233** be selected and included in the installation, but also that Kernel XYZ **211** be selected and included in the installation.

As can be seen, the example of FIG. **6** shows only immediate dependencies, under the assumption that any indirect dependencies are captured by checking the dependency information for the needed package. Thus, dependency **650** does not reflect that Encryption XYZ **223** depends (indirectly) on Kernel XYZ **211**, as this information is represented through dependency **600**. But a person skilled in the art will recognize that database **120** can store all the dependencies for a single package, whether direct or indirect. Thus, dependency **650** can be modified to reflect that Encryption XYZ **223** is also dependent on Kernel XYZ **211**.

Regardless of whether database **120** stores direct or indirect dependencies, or the number of dependencies that are stored, dependency validator **140** can traverse all dependencies in the database.

While FIG. **6** shows security XYZ **233** having only one dependency and encryption XYZ **223** also having only one dependency, a person skilled in the art will recognize that there can be more than one dependency for a selected package or that a selected package can have no dependencies. Indeed, not all packages will necessarily depend on another package.

FIGS. **7**A-**7**B show a flowchart of the procedure used by the dependency validator **140** of FIG. **1** to validate that the necessary package dependencies are included in the customized installation, according to an embodiment of the invention. In FIG. **7**A, at step **710**, the dependency validator begins by identifying a package. In step **720** the dependency validator looks up that package in the dependency database **120**, and checks to see if that package depends on any other packages. If a dependency does not exist, then the dependency validator goes to step **730** and checks to see if there are more packages that need dependency checking. If at step **730** there are more packages to check for dependencies, then the dependency validator returns to step **710** and identifies the next package to move through the flowchart again. However, if at step **730** there are no more packages that need to be checked for dependencies, the dependency validation is complete, and the selected packages can be built into an installation with the assurance that all required dependency packages are included.

If at step **720**, a dependency does exist for the package being checked, then the dependency validator goes to step **735** (in FIG. **7**B), and checks to see if the needed package(s) is/are included in the selected set of packages. If the needed package(s) is/are not selected for inclusion in the installation, then at step **740** the dependency validator alerts the user of the missing package(s) so that the needed package(s) can be selected and included in the installation (or, alternatively, the selected package removed from the installation to avoid including the needed package). If at step **735** the needed package is selected for inclusion in the installation, then the dependency validator goes back to step **730** (in FIG. **7**A) where, as described above, the dependency validator checks to see if there are any more packages that need dependency validation.

While one embodiment of the invention alerts the user to a dependency issue as soon as a problem is identified, another embodiment can check all the packages in the selected set and identify all missing but needed packages before alerting the user of the missing packages. In yet another embodiment, the dependency checker can check for dependency packages as soon as a package is selected. While packages are being selected, it can select the dependency package and note the automatic selection of the additional package (so that the user is aware of this automatic selection). If a needed package is removed from the set of selected packages, then the original package can be removed as well (again, with the system notifying the user of this automatic action). In one embodiment, the alerts of dependency packages can be in the form of a dialog box, but a person skilled in the art will recognize that

there are other ways of alerting the user of missing dependencies, such as text in the selection interface itself, log files or windows, etc.

While the embodiments of dependencies described thus far have included a package with only one dependency package, a package can also be dependent on the existence of at least one package in a set of packages. For example, a particular security package might not require a specific kernel, but rather any kernel of a specified version or greater. In this situation, when the dependency validator sees the particular security package, the dependency validator then checks for a kernel that is in the set of dependency packages that will satisfy the dependency requirement for the security package. Similarly, a selected encryption package can only require that a security package be included for the encryption package to be operable. In this case, it is not important which security package is included, only that one security package is included. A person skilled in the art will also recognize other combinations of dependencies that can be tested for.

FIG. **8** shows a flowchart of the procedure used by the assembler **150** in FIG. **1** with both dependency package validation **140** and conflict resolution **130** for all packages in the installation, according to an embodiment of the invention. In step **810**, the assembler starts with the set of selected packages. In step **820** the assembler checks to see if any packages conflict, as described above with reference to FIG. **5**. If no packages conflict, then the assembler goes to step **830** and validates that the necessary dependency packages are included in the set of selected packages, as described above with reference to FIGS. **7**A-**7**B.

If at step **820** the conflict checker **140** identifies packages that will conflict at run-time, or if at step **830** the dependency validator **130** identifies dependencies that must be selected and included in the installation, the assembler goes to step **840** where it prompts the user to resolve the issues in the selected packages. If at step **830** the dependency validator finds no missing dependencies (and no conflicts), the assembler goes to step **850** where the packages are assembled into an installation, which can then be installed on a computer.

After the conflict checker and dependency validator successfully certify the packages in the installation, the installation is ready to be installed. In one embodiment of the invention, the installation can be installed over a network to a remote server. FIG. **10** shows a system where the computer in FIG. **1** is a bootstrap server capable of installing the installation on to remote servers, according to an embodiment of the invention. Bootstrap server **1000** includes the elements of the computer in FIG. **1**, with a set of packages available for user selection, a conflict checker, a dependency validator, and an assembler with an assembled installation, and an ISO image of the installation. After the installation has been assembled, bootstrap server **1000** remotely boots destination server **1010**, and installs base kernels to destination server **1010**. Then destination server **1010** can install the other selected packages in the customized installation.

In one embodiment of the invention, bootstrap server **1000** could save a backup of the installation, so that the installation could be replicated if necessary. In an embodiment of the invention the backup of the installation can be represented as an ISO image of the installation.

Also, in another embodiment of the invention, bootstrap server **1000** could serve as a cache of all packages in order to have dependency packages available in the future. If a user installs a package in the future that has a needed dependency package that is not included in the user customized installation, then the cache provides access to the dependency package. While this embodiment uses one destination server, it would be obvious to a person skilled in the art that any number of destination servers could be used.

FIG. **11** shows the image storage of FIG. **12** storing two versions of a VM image. After a VM image has been assembled and verified to be operable, the VM image can be stored in image storage **1205** for future deployment or as a backup copy of a deployed image. FIG. **11** shows image storage **1205** storing VM image **1100** and VM image **1105**. VM image **1100** can be a 1.0 version of a custom built VM image, and VM image **1105** can be a later, 2.0 version of the same set of packages.

While FIG. **11** shows two versions of the same package set assembled as VM images, in an embodiment of the invention, other VM images assembled from different package sets can also be stored in image storage **1205**. For example, one VM image can include a kernel XYZ and a security package, while another VM image includes kernel ABC and an encryption package. By storing assembled VM images, VM images that are assembled from a package set and then configured can be stored so that if a configuration of the VM image changes, original VM image (that is known to work correctly) can be re-deployed.

In an embodiment of the invention, image storage **1205** can include information facilitating easy organization of all assembled VM images. In addition to a version number, image storage **1205** can be organized to include a list of the packages that are in a VM image. Image storage **1205** can even include the corresponding versions that are included in a stored VM image. Image storage **1205** can include if the VM image has been deployed, and the target machine of the VM image.

In an embodiment of the invention, image storage **1205** enables administrators responsible for setting up computer systems to customize, assemble, and configure an image on computer system before installing the image on the computer system. Further, image storage **1205** allows the administrator to deploy the same image version on multiple computers, or can enable different VM images to be assembled and configured based on computing requirements. For example, top executives can have one set of requirements, while project managers or engineers can have a different set of requirements. To satisfy the different requirements of different users, the administrator can install different applications of the different computer systems. In the prior art, the administrator would have to install each application (including operating system) directly on the computer.

In an embodiment of the invention, an administrator can create a customized computer environment independent of installing each software package directly on the computer. After assembling a VM image that includes all software applications for a particular user, the administrator can then store the VM image in image storage **1205**. By storing the VM image, if the deployed VM image gets corrupted, or is otherwise changed, the administrator can simply re-deploy the VM image from image storage **1205**.

In another embodiment of the invention is a way to retain information about what packages are included in a particular customer's customized Linux installation. FIG. **9** shows a database table identifying what packages a particular user received in the installation in FIG. **1**, according to an embodiment of the invention. After an installation is built for a user, information is stored to identify what packages were included for the user.

In table **900**, Users in column **910** are matched with Packages in column **950**. User **1** in entry **915** created an installation that included Kernel ABC **951**, Security ABC **952**, and Encryption ABC **953**. In the event that, for example, Encryp-

tion ABC **952** is updated, this new version of the package can be added to the set of packages available for creating a customized Linux installation. However, this updated package can also be distributed to users who have the previous version of Encryption ABC **952**. A query for Encryption ABC **952** in Package table **900** identifies User **1** in entry **915** as having installed Encryption ABC **952**. This way, User **1** can be notified of the update, for example, by e-mail, and can install the update if desired. Similarly if Encryption JKL **956** is updated, User **2** in entry **920** can be notified of the update. Although FIG. **9** shows the package information being stored as a table, a person skilled in the art will recognize that there are other ways of recording package information, such as linked lists, arrays, etc.

While currently it is possible to notify Linux users when updates to packages are available, an embodiment of the invention makes it possible for users of a customized Linux installation to receive notifications only when a package that is in the user's own customized version is updated. In this way, the user does not get bombarded with notices of updates to packages that the user does not have.

Another embodiment of the invention includes a deployment tool that checks for updates to packages in a user's Linux environment. In one embodiment the deployment tool can be set up to automatically use the Internet to see if any patches are available to packages in the user's Linux environment. The deployment tool can be set up to check on a periodic basis, for example every month. A person skilled in the art will recognize that this periodic basis could be any set period, or that this period can be set as a preference of the user.

In addition to automatically checking for updates to packages, the deployment tool can also allow users to run query for updates on demand. Instead of having the update checking as a process that is started automatically, users can manually start the process. A person skilled in the art will recognize that some users might prefer to always have the updates to their packages, while other users might prefer to always be notified of the package updates, in order to approve of the updates before the updates are installed.

In addition to being able to provide customized notifications of package updates, the information in table **900** in FIG. **9** can be used by a Linux vendor as a basis for a customer support agreement. That way, a customer is able to get support for packages included in the customer's installation. Similarly, the vendor knows what packages the customer is entitled to support.

The following discussion is intended to provide a brief, general description of a suitable machine in which certain aspects of the invention may be implemented. Typically, the machine includes a system bus to which is attached processors, memory, e.g., random access memory (RAM), read-only memory (ROM), or other state preserving medium, storage devices, a video interface, and input/output interface ports. The machine may be controlled, at least in part, by input from conventional input devices, such as keyboards, mice, etc., as well as by directives received from another machine, interaction with a virtual reality (VR) environment, biometric feedback, or other input signal. As used herein, the term "machine" is intended to broadly encompass a single machine, or a system of communicatively coupled machines or devices operating together. Exemplary machines include computing devices such as personal computers, workstations, servers, portable computers, handheld devices, telephones, tablets, etc., as well as transportation devices, such as private or public transportation, e.g., automobiles, trains, cabs, etc.

The machine may include embedded controllers, such as programmable or non-programmable logic devices or arrays, Application Specific Integrated Circuits, embedded computers, smart cards, and the like. The machine may utilize one or more connections to one or more remote machines, such as through a network interface, modem, or other communicative coupling. Machines may be interconnected by way of a physical and/or logical network, such as an intranet, the Internet, local area networks, wide area networks, etc. One skilled in the art will appreciated that network communication may utilize various wired and/or wireless short range or long range carriers and protocols, including radio frequency (RF), satellite, microwave, Institute of Electrical and Electronics Engineers (IEEE) 802.11, Bluetooth, optical, infrared, cable, laser, etc.

The invention may be described by reference to or in conjunction with associated data including functions, procedures, data structures, application programs, etc. which when accessed by a machine results in the machine performing tasks or defining abstract data types or low-level hardware contexts. Associated data may be stored in, for example, the volatile and/or non-volatile memory, e.g., RAM, ROM, etc., or in other storage devices and their associated storage media, including hard-drives, floppy-disks, optical storage, tapes, flash memory, memory sticks, digital video disks, biological storage, etc. Associated data may be delivered over transmission environments, including the physical and/or logical network, in the form of packets, serial data, parallel data, propagated signals, etc., and may be used in a compressed or encrypted format. Associated data may be used in a distributed environment, and stored locally and/or remotely for machine access.

Having described and illustrated the principles of the invention with reference to illustrated embodiments, it will be recognized that the illustrated embodiments may be modified in arrangement and detail without departing from such principles. And although the foregoing discussion has focused on particular embodiments and examples, other configurations are contemplated. In particular, even though expressions such as "according to an embodiment of the invention" or the like are used herein, these phrases are meant to generally reference embodiment possibilities, and are not intended to limit the invention to particular embodiment configurations. As used herein, these terms may reference the same or different embodiments that are combinable into other embodiments. Descriptions of the embodiments by reference to Linux are illustrative; the invention can be used with other operating systems and software distributions.

Consequently, in view of the wide variety of permutations to the embodiments described herein, this detailed description and accompanying material is intended to be illustrative only, and should not be taken as limiting the scope of the invention. What is claimed as the invention, therefore, is all such modifications as may come within the scope and spirit of the following claims and equivalents thereto.

The invention claimed is:

1. A method for creating a virtual machine (VM) image, comprising:

selecting a subset of packages from an available set of packages on a computer, the selected subset of packages including at least a first package and a second package and omitting a non-included package;

building a VM image on the computer with the selected subset of packages;

determining if there is a conflict between a first package in the subset of packages and a second package in the subset of packages; and

if there is a conflict between the first package in the subset of packages and the second package in the subset of packages:

recommending the first package to be removed from the VM image;

recommending a third package that does not conflict with the second package at run-time;

removing the first package from the VM image; and

adding the third package to the VM image,

where the VM image is built prior to be installed on a computer.

2. A method according to claim **1**, wherein verifying the subset of packages is operable further comprises:

identifying a first package in the selected subset of packages that depends on a third package in the set of packages; and

adding the third package to the VM image.

3. A method according to claim **1**, wherein validating the subset of packages includes:

deploying the VM image on a development computer; and

testing the VM image on the development computer.

4. A method according to claim **1**, further comprising deploying the VM image on a production computer including a hosting operating system to run the VM image.

5. A method according to claim **4**, further comprising updating the VM image on the production computer after the VM image is deployed on the production computer.

6. A method according to claim **4**, further comprising updating the VM image, including:

creating a second subset of packages by replacing an updated package in the selected subset of packages with the updated selected package;

building an updated VM image with the second subset of packages;

verifying the updated VM image is operable; and

deploying the updated VM image to the production computer after verifying the updated VM image is operable.

7. A method according to claim **4**, further comprising deploying the VM image on a second production computer.

8. A method according to claim **1**, further comprising storing the VM image in a VM storage.

9. A method according to claim **8**, further comprising:

changing a configuration of the VM image; and

deploying the stored VM image to recover from the changed configuration.

10. A method according to claim **1**, wherein selecting a subset of packages includes selecting an operating system.

11. A method according to claim **10** wherein selecting a subset of packages includes selecting at least one application running on the selected operating system.

12. A method according to claim **1**, wherein selecting a subset of packages from an available set of packages includes selecting a subset of Linux packages.

13. A system for building a customized virtual machine (VM) image, comprising:

a set of available software packages;

a computer;

a selector on the computer to select a subset of the set of available software packages, the selected subset including at least a first package and a second package and omitting a non-included package;

an image builder on the computer to build a VM image including the selected subset of the set of available software packages; and

a validator to validate that the first package and the second package do not conflict at run-time and, if the first package and the second package conflict at run-time, to remove the first package from the VM image and add a third package to the VM image that does not conflict with the second package at run-time,

wherein the image builder builds the VM image prior to its deployment on a production computer.

14. A system according to claim **13**, further comprising:

an update to the package; and

a VM image updater to replace the first package with the updated package in the VM image.

15. A system according to claim **14**, further comprising an update installer to install the updated VM image.

16. A system according to claim **13**, comprising a version identifier to identify a version of the VM image.

17. A system according to claim **13**, further comprising a backup copy of the VM image.

18. A system according to claim **13**, wherein the set of available software packages includes a set of Linux software packages.

19. A system according to claim **13**, further comprising:

a production server to run the VM image; and

a host operating system to host the VM image.

20. A system according to claim **19**, further comprising an installer to install the VM image to run on the host operating system.

21. An article, comprising:

a non-transitory storage medium, the non-transitory storage medium having stored thereon instructions, that, when executed by a machine, result in:

accessing a set of available packages;

selecting a subset of the set of available packages, the subset including least a first package and a second package and omitting a non-included package;

assembling the subset of available packages into a virtual machine (VM) image;

determining if there is a conflict between a first package in the subset of packages and a second package in the subset of acka es· and

if there is a conflict between the first package in the subset of packages and the second package in the subset of packages:

automatically removing the first package from the VM image;

automatically selecting a third package that does not conflict with the second package at run-time; and

automatically adding the third package to the VM image, where the VM image is built prior to be installed on a computer.

22. An article according to claim **21**, wherein the non-transitory storage medium has further instructions stored thereon that, when executed by the machine result in:

identifying that the first package in the VM image depends on a third package in the set of packages; and

adding the third package to the VM image.

23. An article according to claim **21**, wherein the non-transitory storage medium has further instructions stored thereon that, when executed by the machine result in notifying the user when an update to a package in the VM image is available on a production computer after the VM image is deployed on the production computer without the user or the production computer having to check for the update to the package.

24. An article according to claim **23**, wherein the non-transitory storage medium has further instructions stored thereon that, when executed by the machine result in installing the update on the production computer.

25. An article according to claim **21**, wherein accessing a set of available software packages includes accessing a set of Linux software packages.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,468,518 B2
APPLICATION NO. : 11/458337
DATED : June 18, 2013
INVENTOR(S) : Wipfel

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On title page 3, column 1, item (56), under Other Publications, line 47, delete "mismatchs" and insert -- mismatches --, therefor.

On title page 3, column 2, item (56), under Other Publications, line 5, delete "Immunnology" and insert -- Immunology --, therefor.

On title page 3, column 2, item (56), under Other Publications, line 13, delete "Resuability" and insert -- Reusability --, therefor.

On title page 3, column 2, item (56), under Other Publications, line 29, delete "htpp" and insert -- http --, therefor.

In the Claims,

In column 14, line 32, In Claim 21, after "including" insert -- at --, therefor.

In column 14, line 39, In Claim 21, delete "acka es" and insert -- packages; --, therefor.

Signed and Sealed this
Eighth Day of September, 2015

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office